PROCESS AND A DEVICE FOR THE FORMATION OF FIBERBOARD

Cross-Reference to Related Applications

This application is a continuation-in-part of copending United States Patent Application Serial Number 09/402,333 filed December 20, 1999, which was the national phase of International Application No. PCT/EP99/00381 filed January 21, 1999

Background of the Invention

The invention relates to a process and a device for the formation of fiberboard. More particularly, the present invention relates to a process and device for the formation of fiberboard composed of wood fibers.

Fiberboard made by process and device of the subject invention is of the type sold as Masonite™ in the United States. Such fiberboard is construction grade material used in the manufacture of furniture, and building components such as interior doors.

The classic production process for such fiberboard is the so-called "wet process". This is the preferred ecological production method because the fiberboard can be produced with virtually no chemical bonding agents. Other construction grade fiberboards, such as particle board and MDF (medium-density fiberboard) utilize a dry process. Non-construction grade fiberboards, such as cardboard and paste board, may also utilize a wet process. However, such fiberboards are manufactured from pulp fibers, not wood fibers, and both the non-construction grade fiberboards and the pulp fibers from which they are made have mechanical properties which are significantly different from those of construction grade fiberboards and the wood fibers from which they are made. For example, the maximum fiber length of the pulp used for the production of non-construction grade fiberboard is approximately 6 mm

while the maximum fiber length of the wood fiber used for the production of construction grade fiberboard is approximately 18 mm.

The pulp suspension has a yield (ratio of fibers to total) of more than 96% and the wood fiber suspension has a yield of only approximately 80%, as the wood fiber suspension includes a substantial quantity of lignin and other additional components. In addition, paper pulp slurry typically has a freeness (according to the Canadian Standard Freeness Test) of ≤ 450 ml CSF, whereas the fiber slurry used in producing construction grade fiberboard typically has a freeness of > 800 ml CSF. Consequently, the wet process used to manufacture non-construction grade fiberboards is significantly different from the one used to manufacture construction grade fiberboard. These differences are sufficient to preclude use of the inventive process for the production of non-construction grade fiberboard, and vice-versa.

The apparatus and process for producing non-construction grade fiberboard is similar to that of paper, with the principal difference between paper and cardboard being the fiber source, with cardboard being generally formed entirely or partially from secondary (recycled) fibers. Cardboard is normally manufactured in a number of layers (e.g. 3 or 4), where the outermost layers may be manufactured from the virgin fibers which are normally used to form paper.

A paper web generally has a basic weight of 30 to 120 gram per m^2 whereas a cardboard web generally has a basic weight of 200 to 400 gram per m^2. Construction grade fiberboard has a basic weight in the range of 1200 to 8000 g per m^2 and may have a thickness of one inch or more before the final heat press. The dewatering behavior of fiberboard is completely different from that of paper and cardboard due to the greater thickness of the web.

The preparation of the fibers upstream of the machine in both cases is totally different and the properties of the fibers too. Pulp fibers

are more flexible and provide a certain net. Wooden fibers are more stiff and normally require a higher pressure is to be worked. For the manufacture of paper and cardboard, it is essential that the fibers will be linked together evenly to provide a regular surface. For the manufacture of fiberboard, it is essential to control the thickness and properly bond the fibers.

The current wet process technology for producing construction grade fiberboard is several decades old. It is ineffective in many process stages and has virtually no means of being regulated. The fibers are reduced in size in a pressurized refiner. Since no (or only very small quantities of) bonding agents are used, the fibers must develop sufficient bonding capacity during the refining process.

The principle of web formation used to date on endless wire machines does have some disadvantages. The present head box technology does not meet the requirements in terms of formation and calibration of the board thickness. Furthermore, web formation according to the endless wire principle requires a vacuum as driving force for the greater part of the water to be removed. This means that the energy consumption of a typical plant is approximately 150 kW. Since the web dewaters to one side, the machine required has to be very long.

Summary of the Invention

In order to avoid the disadvantage of the chemical bonding agents used in dry processes, the aim is to improve the wet process used to date.

The invention is thus characterized by the fiber stock suspension being dewatered on two sides between wires or felts. The energy consumption can be greatly reduced as a result because there is no vacuum required.

A further development of the invention is characterized by dilution water being added locally in order to regulate the board thickness across the web running direction. This is a simple means of evening out the board thickness without requiring a great deal of design work. The thickness is then regulated on the basis of the final board thickness measured.

A favorable configuration of the invention is characterized by headbox lips being set locally to regulate the board thickness across the web running direction. The board thickness can be set approximately using these head box lips, with a more precise board thickness being obtained in combination with the dilution water.

A favorable further development of the invention is characterized by pre- dewatering taking place in a wedge zone. Due to the rising pressure in the wedge zone, even dewatering to a high consistency can be achieved quickly over a short length and without applying a vacuum, where the board thickness can be influenced accordingly by using an adjustable wedge zone.

An advantageous further development of the invention is characterized by the stock being distributed over the working width by means of a cross- flow distributor and by part of the wood fiber stock suspension flow being recirculated to the head box. The optimum basis weight cross-profile can be set as a result of this suspension being recirculated to the head box.

An advantageous configuration of the invention is characterized by the process dewatering to a dry content of more than 40%, preferably more than 45%. As a result, there is a- drop in subsequent pressing time in the hot press (providing a higher throughput), in the amount of heavily loaded filtrate produced during hot pressing, and in the amount of steam needed to evaporate the residual water.

A favorable configuration of the invention is characterized by a top layer being applied after pre-dewatering, with vacuum extraction possibly also being provided in the area where the top layer is applied. Thus, it is possible to obtain good fiberboard surface properties by using small amounts of high-grade fibers without having to alter the composition or quality of the rest of the board.

A favorable further development of the invention is characterized by further dewatering in a wedge zone after the top layer has been applied. As a result, the entire web, including the top layer, can be dewatered well.

An advantageous further development of the invention is characterized by several points being provided with line pressure, for example two to six, preferably three to five. A particularly high final dry content can be achieved as a result.

The invention also refers to a forming device for fiberboard.

This device is characterized by a top wire being provided in the main dewatering zone. With the top wire added, the web can dewater on two sides, virtually halving the dewatering paths, which can also substantially shorten the length of the machine.

An advantageous further development of the invention is characterized by the top wire forming a wedge zone together with the bottom wire. As a result, high and controlled pressing force can be applied to the fiber web, which means that no vacuum is required later for dewatering purposes.

A favorable configuration of the invention is characterized by the wedge zone being of adjustable design. With this adjustable wedge zone, the board thickness can be set particularly well.

An advantageous configuration of the invention is characterized by the bottom wire running essentially horizontally as this limits any disadvantageous effects of gravity.

A favorable further development of the invention is characterized by the wire or felt in the wedge zone being supported by perforated plastic or steel plates, foil strips or table rolls. Only by using a top wire according to the invention is it possible to exploit the advantages of the variants mentioned.

A favorable configuration of the invention is characterized by a second head box being provided in order to apply a top layer.

An advantageous configuration of the invention is characterized by the wedge zones being suitable for pressure loading at the end, which means that the maximum dry content can be obtained after pre-dewatering, regardless of the board thickness to be produced and thus, the web undergoes optimum preparation for the subsequent press zone.

A favorable further development of 'the invention is characterized by several press nips being provided, particularly two to six, preferably between three and five, with the press rolls being arranged almost vertically above one another. This achieves a particularly high final dry content.

A favorable further development of the invention is characterized by the press rolls in the press nips being suitable for individual pressure loading. As a result, the final dry content and the dewatering curve can be controlled effectively.

A favorable configuration of the invention is characterized by the machine frame being suitable for cantilevering. This allows the use of endless woven wires, which provide a longer service life at high pressing forces.

Brief Description of the Drawings

The invention will now be described in examples and referring to the drawings, where

Figure 1 shows a side view of a state-of-the-art plant,

Figure 2 shows a horizontal projection of Figure 1,

Figure 3 shows a side view of a plant according to the invention,

Figure 4 shows a section through the line marked IV-IV in Figure 3,

Figure 5 a section through the line marked V-V in Figure 3, and

Figure 6 provides a sectional view of a headbox.

Detailed Description of the Preferred Embodiment

Figure 1 shows a side view of a endless wire plant 1, with a gravity dewatering zone 2, where the web is guided over rolls 3. Adjoining this is a zone with vacuum rolls 4, where the greater part of the water is extracted from the web. After this zone, more water is pressed out of the web by rolls 5 and 6 mounted in pairs. A typical endless wire plant according to the state of the art is approximately 14 m long for a throughput of 180 tonnes/day.

Figure 2 shows the horizontal projection, illustrating the large number of rolls 3 required, as well as the vacuum rolls 4 and the press rolls 5 and 6. This figure also shows the drive motor 7 with the gearbox 8.

Figure 3 illustrates a fiberboard plant according to the invention. It comprises a head box 22 and an initial dewatering zone 9, where the main dewatering process takes place. This dewatering zone 9 has a bottom wire 10, which runs through the entire plant. It also has a top wire 11 so that the web can dewater in both direction. If no secondary fiber is to be added, there is only one top wire, which also runs through the entire plant. As a result, the web is dewatered evenly over its entire thickness; which is particularly important in fiberboard production. As the water is initially removed from the suspension deposited at the beginning of dewatering zone 9, the fiber web becomes increasingly inflexible and rigid.

The first dewatering zone 9 is adjoined by a further dewatering zone 12, where more water is extracted from the web by vacuum boxes 13. Since only a comparatively very thin layer is fed in here, the amount of water extracted is very small compared with state-of-the-art plants. At the end of this zone 12, a top wire 14 is applied again for further dewatering. This wire 14 also runs through the subsequent press zone 15 with the rolls 16 mounted in pairs. Here, a final dry content of more than 40% is achieved, preferably more than 45%, due to the mechanical dewatering process.

The head box 22 used here can be a cross-flow distributor with a diffuser block and a perforated roll to break up the flocks forming in the suspension. The bottom wire 10 runs through the entire plant in an essentially horizontal position. A wedge 17 is formed in the first dewatering zone 9 together with the top wire 11. The wires 10, 11 run over perforated plates 18 here made of plastic or steel. As an alternative, foil strips or table rolls can be used. The gap height can be set at the end 19 of the wedge zone 17 or the wedge zone 17 can be pressure-loaded. A roll 20, driving against the top wire 11, forms the end of the wedge zone. At the dewatering zone 12, a further headbox 23 can be provided for a top layer. In order to dewater the top layer, a further top wire 14 is provided. Dewatering is assisted by extraction using vacuum (through boxes 13). The top wire 14 and the bottom wire 10 form a further wedge zone 21, which is also adjustable and can be designed for pressure-loading at the end of the zone if necessary. In order to increase the final dry content, the press zone 15 contains two to six, preferably three to five, press nips, i.e. pairs of rolls pressed against one another. The present example shows four such roll pairs 16 which form press nips. A plant of this type has an overall length of approximately 11.5 m for a throughput of approximately 320 tonnes/day, i.e. although production is increased by approximately 80%,

only some 80% of the length required in a state-of-the part plant is needed here. This provides a specific output of approximately 220% compared with state-of-the-art plants.

Figure 4 shows a section through the line marked IV-IV in Figure 3. In this section viewed against the web running direction, the bottom wedge plate 18, a vacuum box 13 and the roll 20 at the end of the wedge zone 17 are all clearly shown. The so-called front side is marked FS and the rear side, where all of the drives and other leads and lines are located, is marked TS.

Figure 5 shows a section through the same point as Figure 4, however viewed in the web running direction. Here, the rear and front sides are reversed compared with Figure 4. In addition to the vacuum box 13 and the wedge plate 18, this illustration also shows the second headbox 23 for the top layer. The suspension to the headbox 23 is fed through a connection pipe 24 coming from the rear side. The water extracted is removed from the vacuum box 13 through a pipe 25.

Figure 6 shows the headbox 22 in detail. The suspension is fed into a cross-flow distributor 26 in the headbox 22 under pressure from a stock feeding pump (not shown). The headbox 22 acts as a pressure boundary such that the pressurized suspension flows through a diffuser block 27, a perforated roll 28, and out of an outlet gap 29. Any defects in the distribution of the wood fiber in the suspension are corrected before the suspension exits the headbox 22, the perforated roller 28 breaking down any knots or flocks that have formed in the suspension and evenly distributing the wood fiber in the liquid of the suspension at the outlet gap 29. Rollers in the forming zone downstream of the headbox of prior art devices acted to break down knots and flocks in the wood fiber. However, the liquid component of the suspension is required for effective distribution of the wood fiber and since the material was already partially dewatered, any particles of wood fiber of

such broken knots and flocks could not be effectively redistributed, effectively leaving the defect intact.

The wood fiber suspension is discharged from the headbox 22 into the wedge zone 17 formed by the top and bottom wires 11, 10. It should be appreciated that the use of top and bottom wires 11, 10 allows the web to be dewatered on both sides simultaneously. This leads to better and more even physical properties of the fiberboard produced by the inventive system. It should also be appreciated that it would not be appropriate to use top and bottom wires in the production of relatively thin materials, such as paper and cardboard, since the belts would produce unacceptable marks in the surface of the material and since the low basic weight of the material precludes dewatering by pressing the material between opposed belts.

The invention is not limited to the examples described. It would also be possible to combine the individual dewatering zones in different ways, depending on the given requirements.